CLAIMS

What is claimed is:

1. A method of starting a turbine engine having a compressor rotationally coupled to a turbine for compressing air, a recuperator for transferring heat from turbine exhaust to the compressed air, and a catalytic combustor to react fuel with the heated compressed air, the method comprising:

rotating the compressor to pass compressed air through the recuperator and the combustor and into the turbine; and

heating the turbine exhaust flow.

2. The method of claim 1, wherein the turbine engine comprises a heater fluidly disposed downstream of the turbine to heat the turbine exhaust.

3. The method of claim 1, wherein heating the turbine exhaust flow comprises:

discontinuing to heat the turbine exhaust flow when the combustor catalyst has reached its light-off temperature.

4. The method of claim 3, comprising:

monitoring the turbine exhaust temperature to determine when the combustor catalyst has reached its light-off temperature.

5. The method of claim 3, wherein heating the turbine exhaust flow comprises:

discontinuing to heat the turbine exhaust flow when the turbine exhaust temperature has reached a predetermined value.

6. The method of claim 1, wherein heating the turbine exhaust flow comprises:

heating the turbine exhaust flow prior to the exhaust flow entering the recuperator.

7. The method of claim 6, wherein the turbine engine comprises a heater fluidly disposed between the turbine outlet and the recuperator to heat the turbine exhaust.

8. The method of claim 1, wherein heating the turbine exhaust flow comprises:

heating the recuperator.

9. The method of claim 8, wherein the turbine engine comprises a heater coupled to the recuperator to heat the recuperator.

10. The method of claim 9, wherein the heater is an electric band heater.

11. The method of claim 8, wherein heating the recuperator comprises:

discontinuing to heat the turbine exhaust flow when the combustor catalyst has reached its light-off temperature.

12. The method of claim 11, comprising:

monitoring the turbine exhaust temperature to determine when the combustor catalyst has reached its light-off temperature.

13. The method of claim 11, comprising:

discontinuing to heat the turbine exhaust flow when the turbine exhaust temperature has reached a predetermined value.

14. The method of claim 1, further comprising:

passing the turbine exhaust exiting from the recuperator through the compressor to be compressed together with air.

15. The method of claim 14, wherein passing the turbine exhaust exiting from the recuperator through the compressor comprises:

discontinuing to pass the turbine exhaust exiting from the recuperator through the compressor when the combustor catalyst reaches its light-off temperature.

16. The method of claim 15, comprising:

monitoring the turbine exhaust temperature to determine when the combustor catalyst has reached its light-off temperature.

17. The method of claim 15, wherein passing the turbine exhaust exiting from the recuperator through the compressor comprises:

discontinuing to pass the turbine exhaust exiting from the recuperator through the compressor when the turbine exhaust temperature has reached a predetermined value.

18. The method of claim 15, wherein heating the turbine exhaust flow comprises:

discontinuing to heat the turbine exhaust flow when the combustor catalyst has reached its light-off temperature.

19. The method of claim 1, wherein heating the turbine exhaust flow comprises:

heating the turbine exhaust flow to transfer heat through the recuperator to the compressed air prior to the compressed air entering the combustor.

20. The method of claim 19, wherein heating the turbine exhaust flow comprises:

heating the turbine exhaust flow to transfer heat through the recuperator to the compressed air prior to the compressed air entering the combustor for the heated compressed air to heat the catalyst in the combustor.

21. The method of claim 20, wherein heating the turbine exhaust flow comprises:

discontinuing to heat the turbine exhaust flow when the combustor catalyst has reached its light-off temperature.

22. The method of claim 21, comprising:

monitoring the turbine exhaust temperature to determine when the combustor catalyst has reached its light-off temperature.

23. The method of claim 21, wherein heating the turbine exhaust flow comprises:

discontinuing to heat the turbine exhaust flow when the turbine exhaust temperature has reached a predetermined value.

24. The method of claim 21, further comprising:

discontinuing to pass the turbine exhaust exiting from the recuperator through the compressor to be compressed together with air when the combustor catalyst has reached its light-off temperature.

25. The method of claim 24, comprising:

monitoring the turbine exhaust temperature to determine when the combustor catalyst has reached its light-off temperature.

26. The method of claim 24, wherein passing the turbine exhaust exiting from the recuperator through the compressor comprises:

discontinuing to pass the turbine exhaust exiting from the recuperator through the compressor when the turbine exhaust temperature has reached a predetermined value.

27. The method of claim 1, comprising:

providing fuel to the combustor when the catalyst has reached its light-off temperature.

28. The method of claim 27, comprising:

monitoring the turbine exhaust temperature to determine when the combustor catalyst has reached its light-off temperature.

29. The method of claim 27, comprising:

providing fuel to the combustor when the turbine exhaust temperature has reached a predetermined value.

30. The method of claim 1, comprising:

providing fuel to the combustor together with the compressed air.

31. The method of claim 30, wherein heating the turbine exhaust flow comprises:

combusting fuel in the turbine exhaust flow.

32. The method of claim 31, wherein the turbine engine comprises a heater fluidly disposed downstream of the turbine to combust fuel in the turbine exhaust.

33. A turbine engine, comprising:

a turbine;

a compressor rotationally coupled to the turbine for compressing air;

a recuperator fluidly coupled to the compressor and to the turbine for transferring heat from turbine exhaust to the compressed air;

a catalytic combustor fluidly coupled to the turbine and to the recuperator for reacting fuel with the heated compressed air; and

a heater fluidly coupled to the turbine outlet for heating the turbine exhaust flow.

34. The engine of claim 33, wherein the heater comprises:

a heater for heating the turbine exhaust flow until the combustor catalyst has reached its light-off temperature.

35. The engine of claim 34, comprising:

a controller connected to the engine for monitoring the turbine exhaust temperature to determine when the combustor catalyst has reached its light-off temperature.

36. The engine of claim 34, wherein the heater comprises:

a heater for heating the turbine exhaust flow until the turbine exhaust temperature has reached a predetermined value.

37. The engine of claim 33, wherein the heater is fluidly disposed downstream of the turbine and upstream of the recuperator exhaust side.

41. The engine of claim 33, wherein the heater is coupled to the recuperator to heat the recuperator.

42. The engine of claim 41, wherein the heater comprises:

a heater for heating the recuperator until the combustor catalyst has reached its light-off temperature.

43. The engine of claim 42, comprising:

a controller connected to the engine for monitoring the turbine exhaust temperature to determine when the combustor catalyst has reached its light-off temperature.

44. The engine of claim 42, wherein the heater comprises:

a heater for heating the recuperator until the turbine exhaust temperature has reached a predetermined value.

45. The engine of claim 41, wherein the heater is an electric band heater.

46. The engine of claim 33, comprising:

a passage disposed fluidly between the outlet of the recuperator exhaust side and the compressor inlet for passing the turbine exhaust exiting from the recuperator through the compressor to be compressed together with air.

47. The engine of claim 46, comprising:

a controller connected to the engine for controlling the passage to pass the turbine exhaust exiting from the recuperator through the compressor until the combustor catalyst reaches its light-off temperature.

48. The engine of claim 47, wherein the controller comprises:

a controller connected to the engine for monitoring the turbine exhaust temperature to determine when the combustor catalyst has reached its light-off temperature.

49. The engine of claim 47, wherein the controller comprises:

a controller connected to the engine for controlling the passage to pass the turbine exhaust exiting from the recuperator through the compressor until the turbine exhaust temperature has reached a predetermined value.

50. The engine of claim 47, wherein the heater comprises:

a heater for heating the turbine exhaust flow until the combustor catalyst has reached its light-off temperature.

51. The engine of claim 33, wherein the heater comprises:

a heater for heating the turbine exhaust flow to transfer heat through the recuperator to the compressed air prior to the compressed air entering the combustor.

52. The engine of claim 51, wherein the heater comprises:

a heater for heating the turbine exhaust flow to transfer heat through the recuperator to the compressed air prior to the compressed air entering the combustor for the heated compressed air to heat the catalyst in the combustor.

53. The engine of claim 52, wherein the heater comprises:

a heater for heating the turbine exhaust flow until the combustor catalyst has reached its light-off temperature.

54. The engine of claim 53, comprising:

a controller connected to the engine for monitoring the turbine exhaust temperature to determine when the combustor catalyst has reached its light-off temperature.

55. The engine of claim 53, wherein the heater comprises:

a heater for heating the turbine exhaust flow until the turbine exhaust temperature has reached a predetermined value.

56. The engine of claim 52, comprising:

a passage disposed fluidly between the outlet of the recuperator exhaust side and the compressor inlet for passing the turbine exhaust exiting from the recuperator through the compressor to be compressed together with air until the combustor catalyst has reached its light-off temperature.

57. The engine of claim 56, comprising:

a controller connected to the engine for monitoring the turbine exhaust temperature to determine when the combustor catalyst has reached its light-off temperature.

58. The engine of claim 56, wherein the heater comprises:

a heater for passing the turbine exhaust exiting from the recuperator through the compressor until the turbine exhaust temperature has reached a predetermined value.

59. The engine of claim 33, comprising:

a fuel pump fluidly connected to the combustor for providing fuel to the combustor when the catalyst has reached its light-off temperature.

60. The engine of claim 59, comprising:

a controller connected to the engine for monitoring the turbine exhaust temperature to determine when the combustor catalyst has reached its light-off temperature.

61. The engine of claim 59, comprising:

a fuel pump fluidly connected to the combustor for providing fuel to the combustor when the turbine exhaust temperature has reached a predetermined value.

62. The engine of claim 33, comprising:

a fuel pump fluidly connected to the combustor for providing fuel to the combustor together with the compressed air.

63. The engine of claim 62, wherein the heater comprises:

a heater for combusting fuel in the turbine exhaust flow.

64. A turbogenerator system, comprising:

a turbine;

a compressor rotationally coupled to the turbine for rotating therewith to compress air;

a recuperator fluidly coupled to the compressor and to the turbine for transferring heat from turbine exhaust to the compressed air;

a catalytic combustor fluidly coupled to the turbine and to the recuperator for reacting fuel with the heated compressed air;

a heater fluidly coupled to the turbine outlet for heating the turbine exhaust flow;

a motor/generator rotationally coupled to the turbine for rotating therewith to produce power;

a DC output bus for providing the power to a load; and

a bi-directional motor/generator power converter connected between the motor/generator and the DC bus to automatically control system speed by varying the flow of power, after system startup, from the motor/generator to the DC bus and from the DC bus to the motor/generator.

65. The system of claim 64, wherein the motor/generator comprises:

a motor/generator connected between the turbine and the motor/generator power converter for transferring power from the turbine to the motor/generator power converter to reduce system speed, and for transferring power from the motor/generator power converter to the turbine to increase system speed.

66. The system of claim 65, comprising:

a fuel control system connected to the combustor for automatically controlling turbine temperature by varying a flow of fuel to the combustor.

67. The system of claim 66, wherein the fuel control system comprises:

a fuel control system connected to the combustor for automatically controlling the turbine temperature to a temperature selected in accordance with the system speed to which the system is being controlled.

68. The system of claim 67, comprising:

a bi-directional output power converter connected between said DC bus and the load for automatically controlling a DC bus voltage by varying the power applied from the DC bus to the load and from the load to the DC bus.

69. The system of claim 68, comprising:

a power controller operating the motor/generator power converter, the output power converter, and the fuel control system to automatically control turbine temperature, system speed, and a DC bus voltage.

70. A turbogenerator system, comprising:

a turbine;

a compressor rotationally coupled to the turbine for rotating therewith to compress air;

a recuperator fluidly coupled to the compressor and to the turbine for transferring heat from turbine exhaust to the compressed air;

a catalytic combustor fluidly coupled to the turbine and to the recuperator for reacting fuel with the heated compressed air;

a heater fluidly coupled to the turbine outlet for heating the turbine exhaust flow;

a passage disposed fluidly between the outlet of the recuperator exhaust side and the compressor inlet for passing the turbine exhaust exiting from the recuperator through the compressor to be compressed together with air;

a motor/generator rotationally coupled to the turbine for rotating therewith to produce power;

a DC output bus for providing the power to a load; and

a bi-directional motor/generator power converter connected between the motor/generator and the DC bus to automatically control system speed by varying the flow of power, after system

startup, from the motor/generator to the DC bus and from the DC bus to the motor/generator.

71. The system of claim 70, wherein the motor/generator comprises:

a motor/generator connected between the turbine and the motor/generator power converter for transferring power from the turbine to the motor/generator power converter to reduce system speed, and for transferring power from the motor/generator power converter to the turbine to increase system speed.

72. The system of claim 71, comprising:

a fuel control system connected to the combustor for automatically controlling turbine temperature by varying a flow of fuel to the combustor.

73. The system of claim 72, wherein the fuel control system comprises:

a fuel control system connected to the combustor for automatically controlling the turbine temperature to a temperature selected in accordance with the system speed to which the system is being controlled.

74. The system of claim 73, comprising:

a bi-directional output power converter connected between said DC bus and the load for automatically controlling a DC bus voltage by varying the power applied from the DC bus to the load and from the load to the DC bus.

75. The system of claim 74, comprising:

a power controller operating the motor/generator power converter, the output power converter, and the fuel control system to automatically control turbine temperature, system speed, and a DC bus voltage.